Tailoring Clean-Up Strategies Based on the Contaminant

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Service Beyond Analysis

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Tailoring Clean-Up Strategies Based on the Contaminant

Contents:

- Why tailor a clean-up strategy?
- How do you get the hypotheses tested?
- What did we learn?
- What does it say?

Tailoring Clean-Up Strategies Based on the Contaminant

Why is tailoring a cleanup strategy important?

Lake Michigan Spill 2019, NHPR.ORG

Exxon Valdez 1989, RGB Ventures

Deepwater Horizon 2010; Louisiana Governors Office

Tailoring Clean-Up Strategies Based on the Contaminant

Why is tailoring a clean-up strategy important?

- Chemistry of oil
- Floating oil and residuals in water
- Log Kow:

benzene (2.13) > toluene (2.69) > ethylbenzene (2.84) > xylenes (3.15)

- General abundances of chemicals in oil
- Composition in oil vs in water
- Environmental factors

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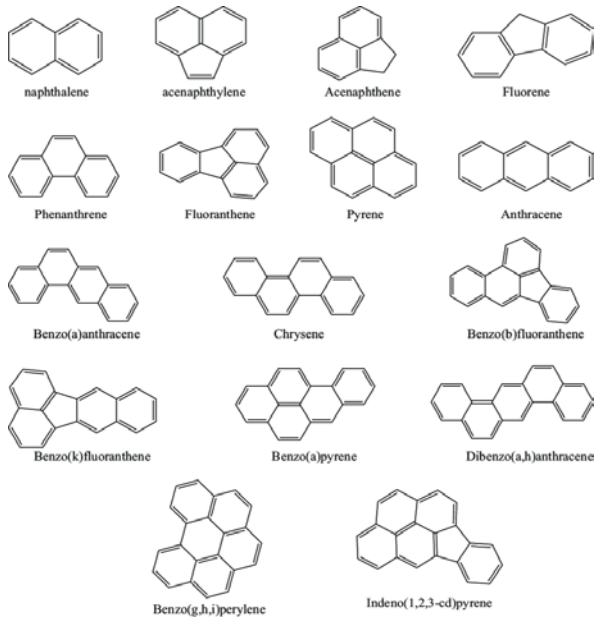
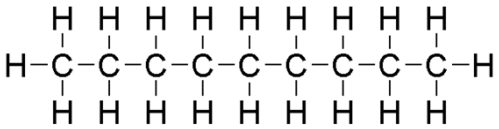
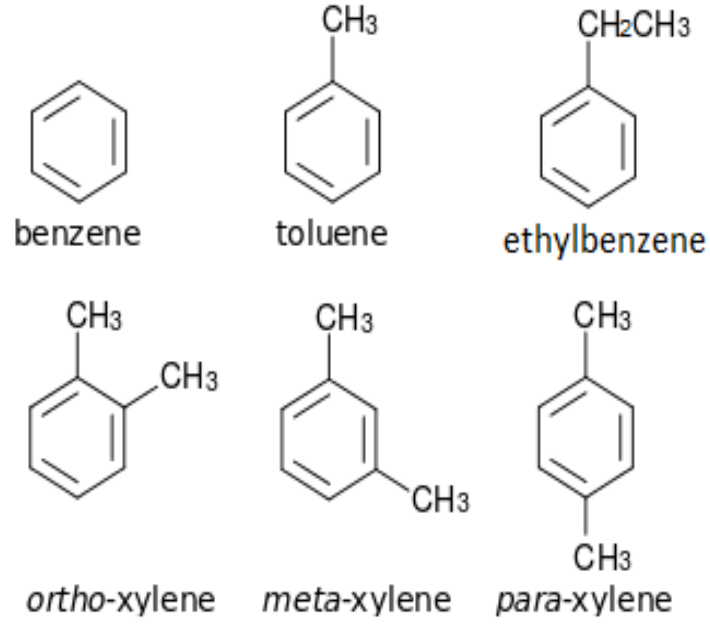
Studied Compounds:



Polycyclic Aromatic Hydrocarbons



Aliphatic Hydrocarbons
(Part of F1-F4)



BTEX

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Research Questions

- Does the chemistry of oil affect the release of chemicals?
- Would the abundance of chemicals in oil be reflected in water?
- Does the time of exposure matter?
- Is the clean-up completed when the oil is collected?
- What are odds and mysteries for future studies?

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Experiment

- 150 g of water in a glass jar
- 10 g of crude oil
- Intervals: 6h, 24h and 192h
- Bottom layer collected and tested
- Target tests: BTEX, F1-F4, PAHs

	Viscosity Kinematic	Density
Crude Oil	m^2/s	g/cm^3
A – light	11.540	0.8556
B - heavy	991.84	0.9528

1) Prep:
- Glassware
- Crude A&B

2) Spike:
- Water
- Oil
- Blank

3) Time Intervals:
- 6 h
- 24 h
- 192 h

4) Extraction:
Subsurface water

5) Sample Treatment:
Liquid-liquid extraction

6) Instrumentation:
- GC-FID-MS
- Density
- Viscosity

7) Data Processing
- ChemStation

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What did we learn?

BTEX

Parameter	Light Oil			
	Concentration µg/L			
	6h	24h	192h	RDL*
Benzene	42.8	343	422	0.5
Toluene	85.2	433	553	0.3
Ethylbenzene	9.5	49.1	53	0.5
Xylenes	28	111	91.4	0.5

Parameter	Heavy Oil			
	Concentration µg/L			
	6h	24h	192h	RDL
Benzene	87.1	134	7.9	0.5
Toluene	88.9	117	64	0.3
Ethylbenzene	9.4	8.8	13	0.5
Xylenes	43	39.4	53.4	0.5

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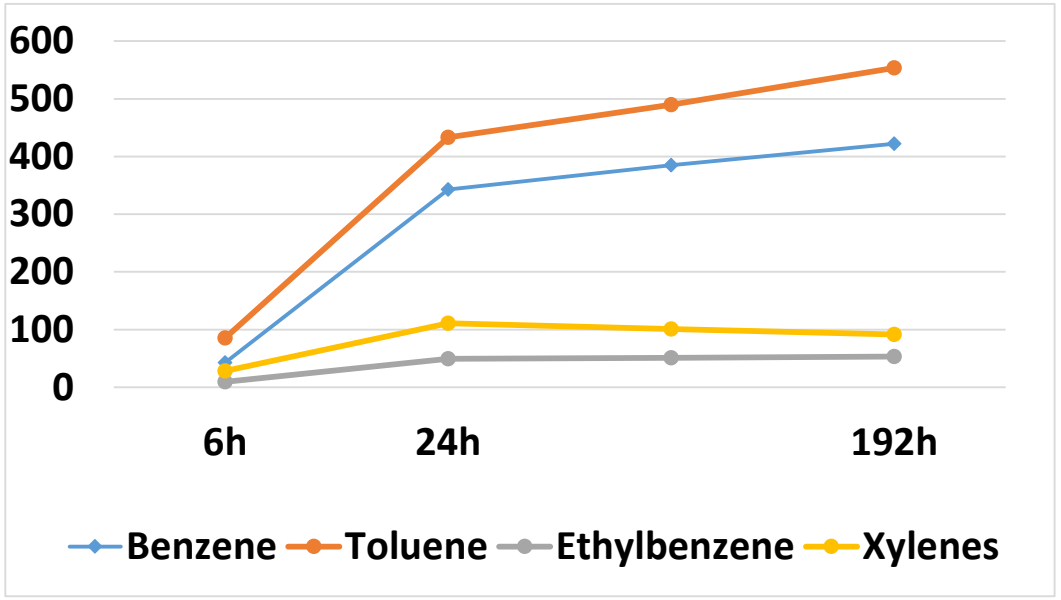
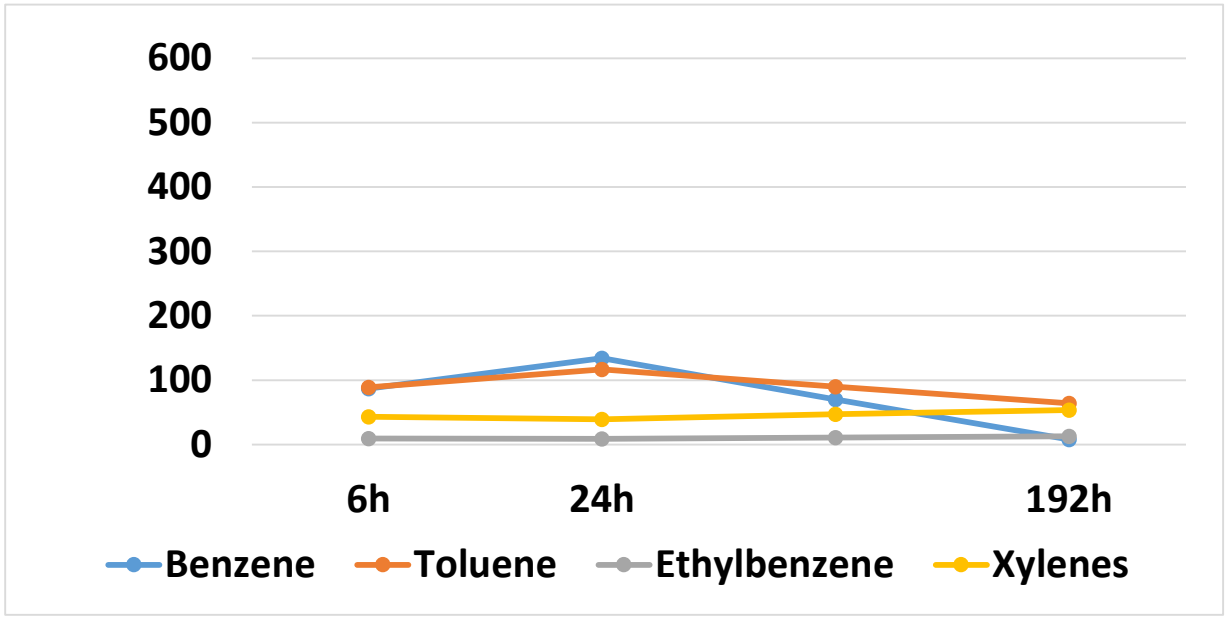
What did we learn?

BTEX (ug/L)



Light oil



Heavy oil

Tailoring Clean-Up Strategies Based on the Contaminant

What did we learn?

F1-F4

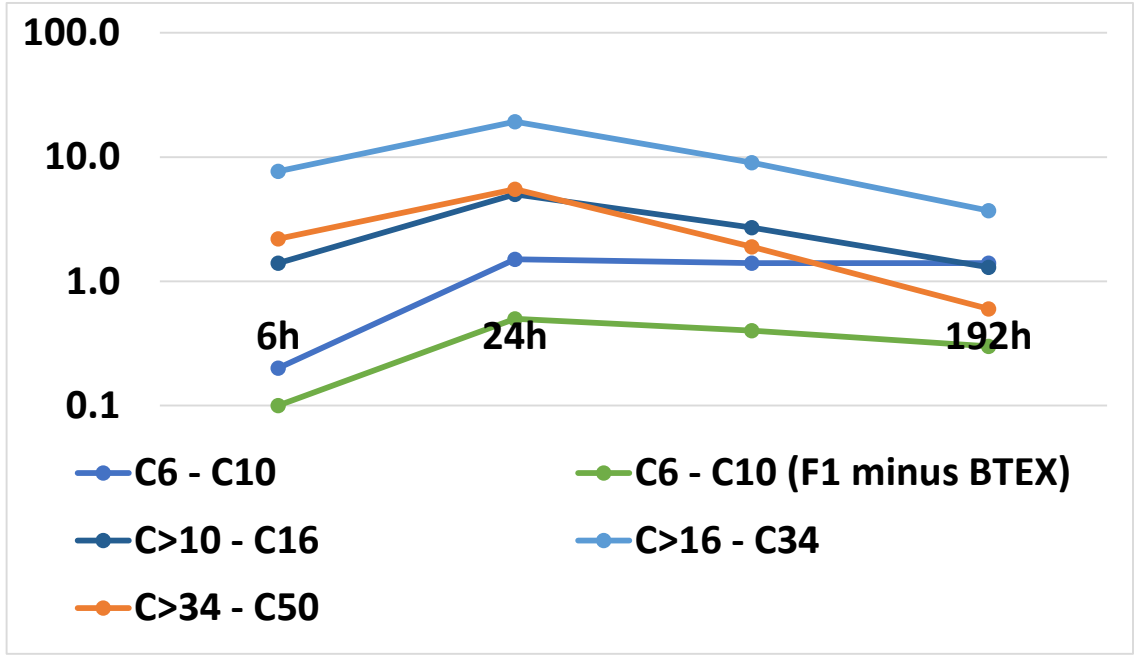
Parameter	Light Oil				
	Concentration mg/L				
	6h	24h	192h	RDL	Oil
C_6 - C_{10} (F1)	0.2	1.5	1.4	0.1	39.9
C_6 - C_{10} (F_1 minus BTEX)	0.1	0.5	0.3	0.1	37.2
C_{10} - C_{16} (F2)	1.4	5.0	1.3	0.5	5743
C_{16} - C_{34} (F3)	7.7	19.3	3.7	0.5	9946
C_{34} - C_{50} (F4)	2.2	5.5	0.6	0.5	36

Parameter	Heavy Oil				
	Concentration mg/L				
	6h	24h	192h	RDL	Oil
C_6 - C_{10} (F1)	0.7	0.7	0.6	0.1	49
C_6 - C_{10} (F_1 minus BTEX)	0.5	0.4	0.5	0.1	46.6
C_{10} - C_{16} (F2)	4.5	3.2	7.0	0.5	595
C_{16} - C_{34} (F3)	13.7	8.4	18.2	0.5	678
C_{34} - C_{50} (F4)	3.8	2.5	4.6	0.5	NA

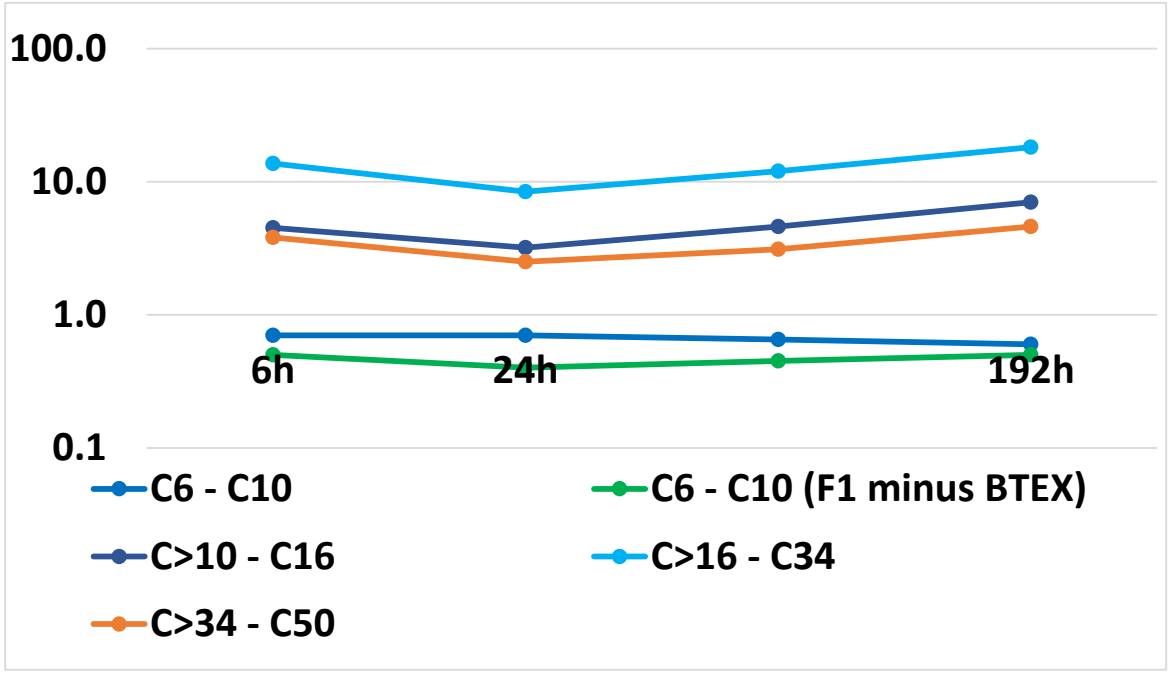
Tailoring Clean-Up Strategies Based on the Contaminant

What did we learn?

F1-F4



Light Oil



Heavy Oil

Tailoring Clean-Up Strategies Based on the Contaminant

What did we learn?

PAHs

Parameter	Water exposed to and the original light oil				Water exposed to and the original heavy oil				
	Concentration µg/L								
	6h	24h	192h	Light Oil	6h	24h	192h	Heavy Oil	RDL
1-Methylnaphthalene	2.15	16.8	5.83	1244.17	1.95	1.14	2.03	66.18	0.05
2-Methylnaphthalene	1.18	8.77	2.81	1053.89	1.69	1.03	1.92	97.51	0.05
Perylene	<0.05	<0.05	<0.05	1.14	0.45	0.34	0.57	26.82	0.05
Naphthalene	1.98	6.75	5.60	385.51	1.45	1.04	1.67	49.44	0.05
Acenaphthylene	0.11	0.8	0.09	0.9	<0.05	<0.05	<0.05	0.53	0.05
Acenaphthene	<0.05	<0.05	<0.05	12.91	<0.05	<0.05	<0.05	7.33	0.05
Fluorene	1.22	3.63	0.88	139.97	0.86	0.62	0.68	36.28	0.05
Phenanthrene	3.58	8.49	1.64	388.41	0.95	0.64	1.09	54.91	0.05
Anthracene	<0.050	<0.050	<0.050	5.79	<0.05	<0.05	<0.05	11.82	0.050
Fluoranthene	<0.05	<0.05	<0.05	14.34	<0.05	<0.05	<0.05	13.06	0.05
Pyrene	0.33	0.89	<0.05	21.4	0.98	0.48	0.98	41.22	0.05
Benzo[a]anthracene	<0.050	<0.050	<0.050	166	<0.05	<0.05	0.210	6.18	0.050
Chrysene	<0.05	<0.05	<0.05	77.01	<0.05	<0.05	<0.05	42.17	0.05
Benzo[b+j]fluoranthene	<0.05	<0.05	<0.05	15.25	<0.05	<0.05	0.15	15.64	0.05
Benzo[k]fluoranthene	<0.05	<0.05	<0.05	0.83	<0.05	<0.05	<0.05	2.74	0.05
Benzo[a]pyrene	<0.035	<0.035	<0.035	0.99	0.203	<0.035	<0.035	4.42	0.035
Benzo[e]pyrene	<0.05	0.046	<0.05	19.44	0.25	0.12	0.26	13.2	0.05
Indeno[1,2,3-cd]pyrene	<0.05	<0.05	<0.05	0.89	<0.05	<0.05	<0.05	5.45	0.05
Benzo[ghi]perylene	<0.05	<0.05	<0.05	3.06	0.19	<0.05	0.19	8	0.05
Dibenzo[ah]anthracene	<0.040	<0.040	<0.040	2.18	<0.04	<0.04	<0.04	1.57	0.040

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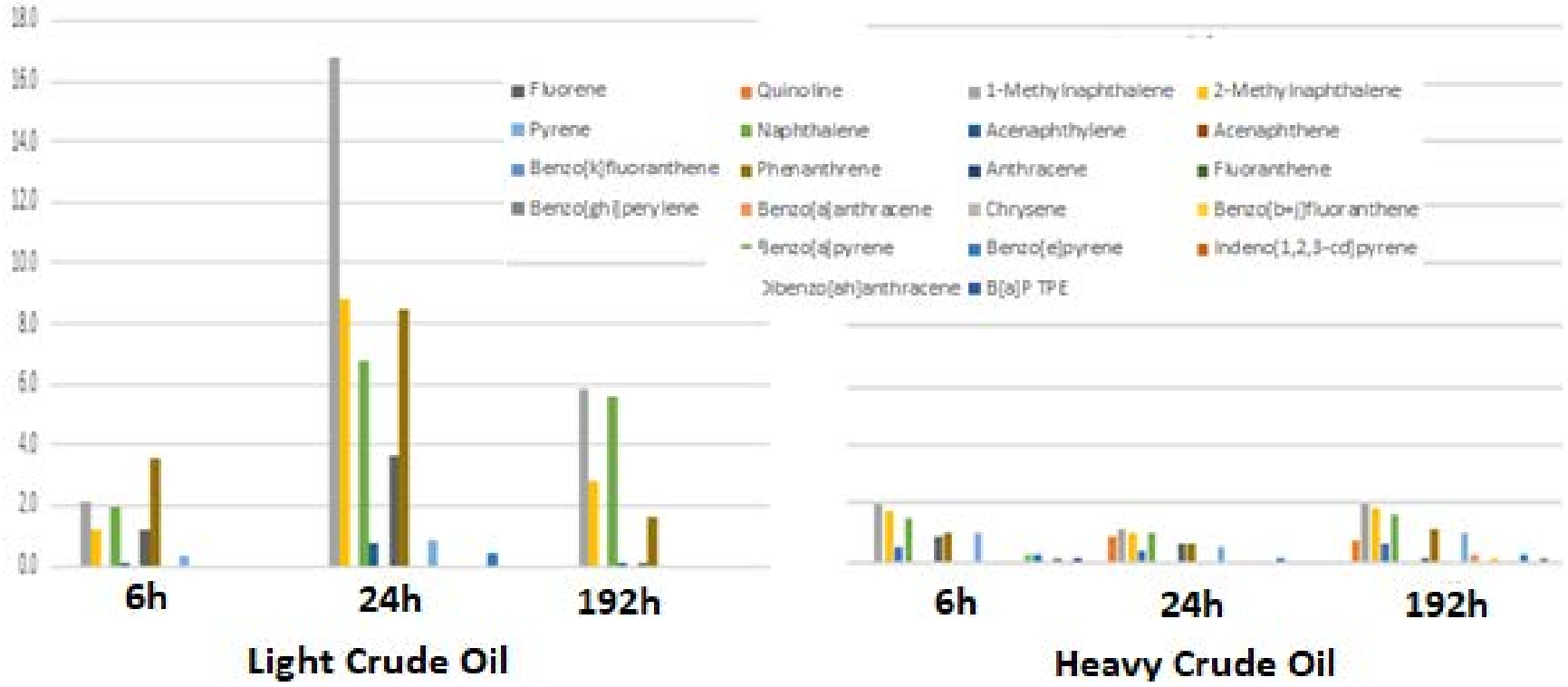
What did we learn?

PAHs (ug/L)



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What does it say?

- Concentrations in water follows original concentrations in oil.
- The relative concentration of oil in water does not follow the similar trend.
- The release of benzene and toluene were higher than other BTEX.
- The release of benzene and toluene in lighter oil continued towards the final time interval.
- Heavier crude resists the release of chemicals due to kinematic viscosity and density.

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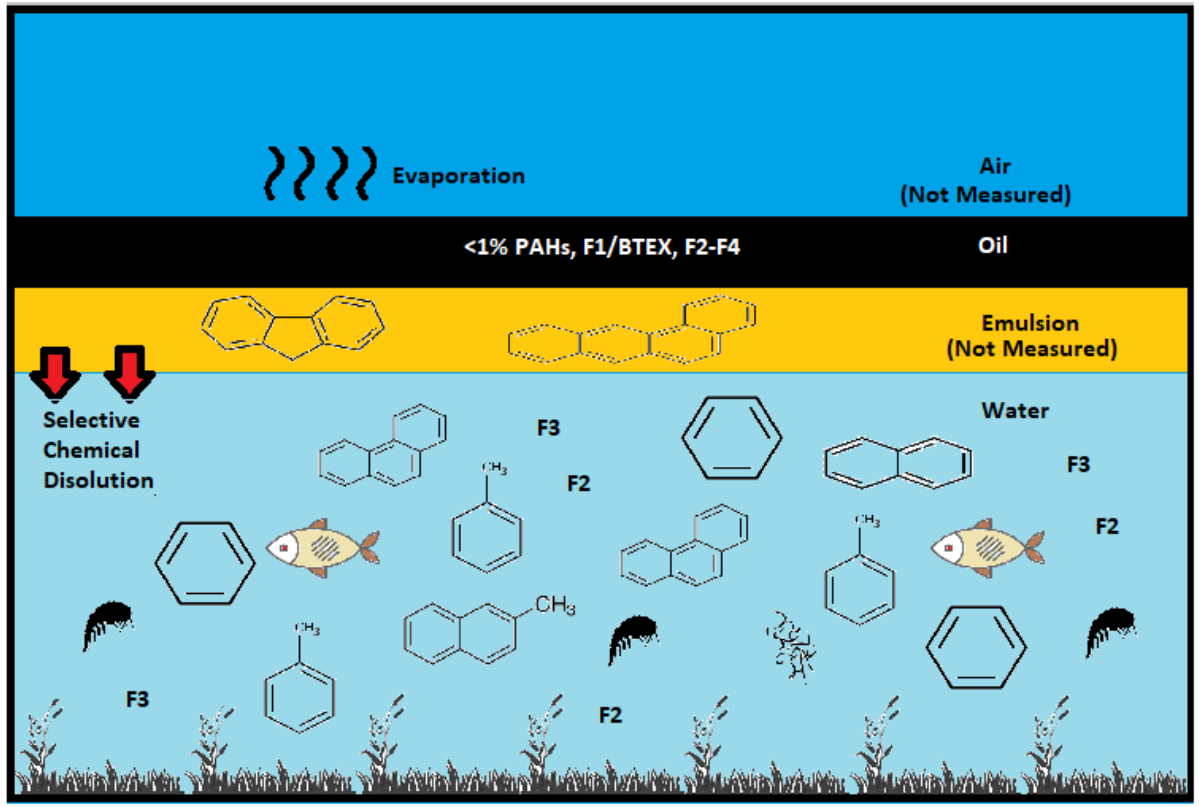
What does it say? (cont . . .)

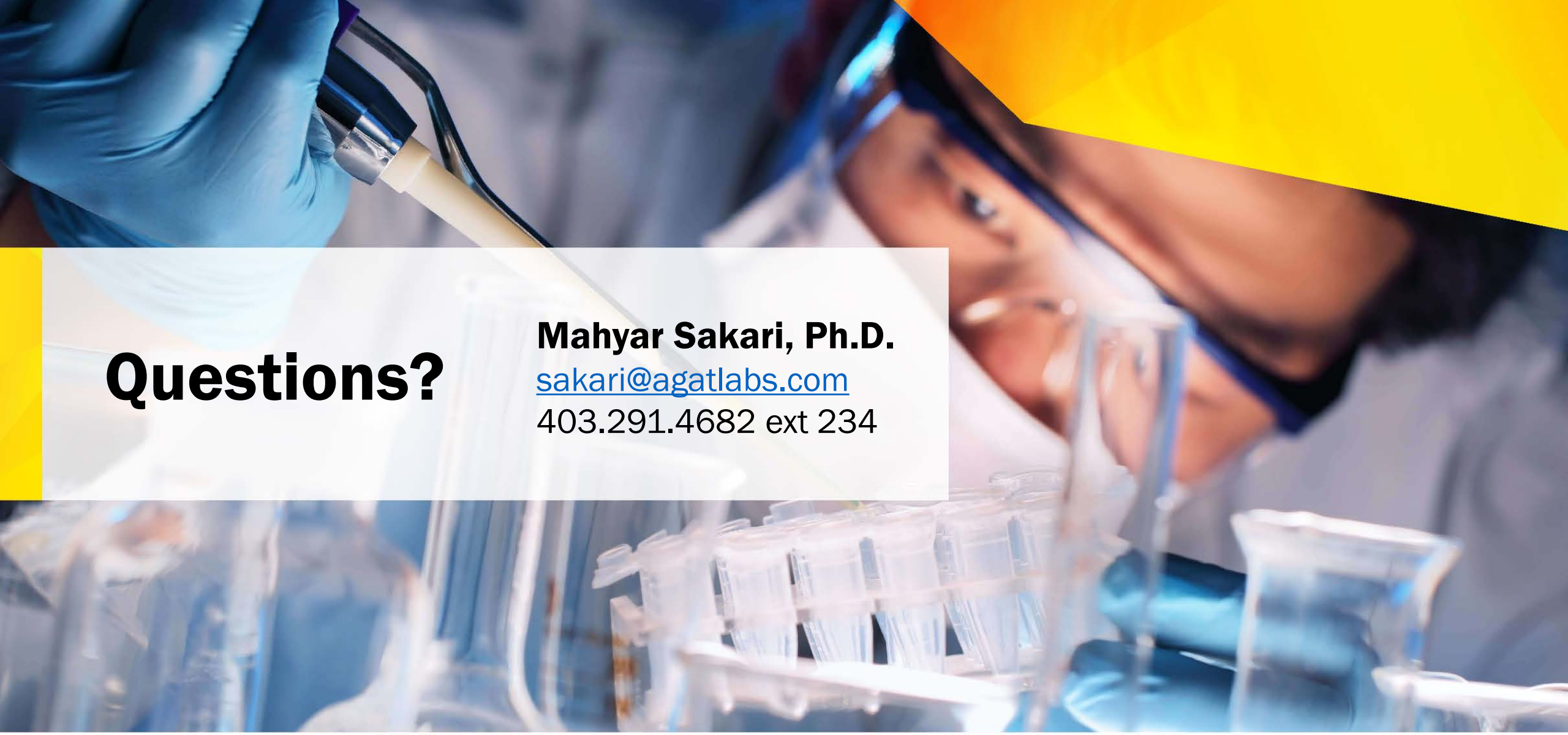
- The lighter oil releases more toxic PAHs and heavier crude more carcinogenic PAHs
- The release of chemicals from crude oil to water follows, the chemistry, abundance, solubility, density and viscosity
- The first 24h is crucial in spill control.
- Lakes are under the bigger threat than ocean where a lower buoyancy exists.

Tailoring Clean-Up Strategies Based on the Contaminant

What does it say? (cont..)

- Emulsion layers between the oil in surface and water beneath acts as an intermediate layer performing a catch and release in time intervals.
- If we include this finding in a clean-up strategy, should we consider a tailored method?
- If this could get tested in a larger scale and results are confirming, should we have additional clean-up?
- Examples of tailored clean-up such as delayed clean-up based on type of oil, multi-stage clean-up to remove residuals, etc.





Questions?

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